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"The Effects of the Earthquake in 1897 on the Shaistaganj Division of the Assam-Bengal Railway."

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The Southern Section of the Assam-Bengal metre-gauge railway runs in a north-westerly direction from Chittagong to Laksam, a distance of 81 miles, thence in a northerly direction to Akhaura, at 125 miles, and thence in a north-easterly direction to Badarpur, at 252 miles, to which point the main line was opened in June 1897. The Shaistaganj division at that date began at the 133rd mile, and ended at the 229th mile, a little short of the northern terminus. Parallel to, and eastward of the Shaistaganj division of the railway is a range of mountains, the drainage area of which is crossed by the railway. This section of the railway nowhere attains any considerable altitude; the highest point is only 146·50 feet, and the lowest 33·00 feet above mean sea-level, the line for the most part traversing an alluvial plain. There are, however, two points where it cuts through two ranges of low hills covered with dense jungle. These hills for the most part consist of sand, resting on clay, the sand in some places being 60 feet deep, and the railway cuttings being sometimes 80 feet deep and even more.

The alluvial plain is studded with clusters of hills, called "tilas" by the inhabitants. A tila may be only 2 feet or 3 feet out of the plain; on the other hand, some attain a general altitude of 50 feet. They generally consist of moorum, covered with sand, and are used as homestead land; where not so used they are covered with dense jungle. The land between the tilas is cultivated, except where it consists of bog, often of great depth. Crossing these bogs constituted the chief difficulty in constructing this portion of the railway, and no formidable engineering difficulty was encountered. The largest river, the Manu, is crossed by four spans of 60-foot and one of 40-foot girders, and, to accommodate the Manu spills, an aggregate waterway of about 1,000 feet has been allowed.

The earthquake recorded in this Paper occurred at 4.30 (Madras time) in the afternoon of the 12th June, 1897. It lasted about 3½ minutes, the oscillations being from east to west at the rate of ten a second. Speaking generally, the earthquake did little or no damage to the railway where it runs through the hills and tilas. The wing-walls of a few bridges were cracked, but not destructively, the earthwork and permanent way being left uninjured. On the plain, however, and between the tilas, the damage was enormous. The damage on the plain will be described more in detail further on. Between the tilas, if the bank crossed a bog, it was shaken down into it. At one place, where the line crosses a bog, known as the Dulcherra, at least 30 feet deep and about 1,000 feet wide, and where the filling of bank across the bog had proved very troublesome, the earthquake shook the bank down into the bog, and left it with almost as much to fill again as when work on it was begun.

The earthquake, in crossing the plains, seems to have acted in a wave-like manner. Where the surface of the plain is cut by a river or stream, it left the river bank in a succession of steps or ripples. The waterway was invariably reduced, though the impulse seemed to reach the river sometimes from the left bank and sometimes from the right. At the Markhal, at 212 miles, it seems to have come from both banks, the piers all leaning towards the centre of the river. At the Khawai the impulse was from the right bank, and at the Dhulai, 30 miles north, it was from the left. The destructive energy of the earthquake was nowhere more manifest than near Shaistaganj, although so far from the focus of the disturbance. Here the line crosses an alluvial plain drained by the Khawai river, and the earthquake effect may be considered typical of such convulsions, and worthy of study in detail. Near the Khawai, the bank opened out in great fissures; these run underneath, parallel to and across the line of railway, and afford no safe indication of the line of force of the earthquake; on the ordinary ground-level, mud and sand welled out of the fissures and did much damage to the crops. One of the most extraordinary effects of the earthquake occurred at a point 1½ mile east of the Khawai. Here the whole road, bank, rails, and bridges, for a length of over a mile, was shifted about 6 feet to 8 feet northwards. At Daragaon 5 miles east of Shaistaganj, the west end of the station-yard, for its whole width of 4 chains, sank 2 feet to 3 feet into the ground; as the ground sank, water welled up, and nothing could be more terrifying to behold than the manner in which the very ground seemed to dissolve in the welling water.

It is worth noting that the ground on which the bank on this part of the line was super-imposed, sank under the weight of the bank (this was the case almost everywhere that the line is in alluvium), the water standing at the toe of the slope to a depth of several inches. On the rails and sleepers the effect was as terrible as on the bank; in some places the rails parted at the joints, leaving gaps, varying in length between a few inches and as much as 2 feet 3 inches in one case; in others, the rails buckled right across the road; within 4 miles of the Khawai there were seven such kinks.

The bridges suffered chiefly from the narrowing of the waterway, causing butting of the girders, and thereby pushing off the ballast walls, but in many cases the piers were tilted so that they no longer supported the girders, and these were left suspended only by the rails. The type of bridge which suffered most was the ordinary splayed wing-wall type; box abutments suffered very little, comparatively speaking, and there was no case of a simple structure like a pier showing even a crack, though many were tilted, some in one direction and others in the opposite. As already mentioned, bridges founded on non-alluvial formations suffered little or no harm; in addition, it is interesting to note how certain bridges, founded in alluvial clay, escaped scatheless; one in particular, a 12-foot girder-bridge of the splayed wing-wall type, situated in the midst of the area of maximum disturbance, $\frac{1}{4}$-mile north of the Khawai and $\frac{1}{2}$-mile south of the scene of the total displacement of bank rails, bridges, and centre line, showed not even a crack. It not only escaped harm from the great convulsion of the 12th June, but also from the lesser but still very severe earthquakes which succeeded it.

To restore the line to a condition fit for running would have been easier had the earthquake occurred in any of the earlier months of the year; the ordinary labour in Sylhet, the district through which this part of the railway runs, is all imported from countries west of Calcutta, and it is the custom of the labourers to return to their homes at the beginning of the rains. The only available labour was the permanent-way staff, assisted by a few men picked up locally. Fortunately, three trains, used for leading ballast, were at work in the division; when the earthquake occurred two of these were at work in the hills, and were available for service at once, while the third was standing delivering a load on a bank near the Manu River. The whole train, engine and wagons, subsided with the bank into the ground, but at this spot the shock was not severe, and the train was got out and into working order within a week.

Each difficulty was coped with on its merits; the rails were raised, and, if the ground had sunk, earth was led to the site by train. Where the rails were kinked they were removed, and new pieces were put in, whole rails being obviously impossible; on the bridges, the girders were put in line, and if the bearing surface was disturbed, they were packed with wooden chocks. When the shoe plate was insufficiently supported by a pier, sleeper stacks were built beneath to support the girder. At the Khawai, arrangements were made for a diversion, with a temporary timber bridge across the river. In the meantime, passengers were to walk across the bridge, while the train was to be pushed across slowly to the charge of another engine on the further side.

By these means traffic was resumed on the 1st August, seven weeks after the earthquake; the temporary arrangements described in the foregoing proved adequate for the traffic until after the rains, when permanent repairs were begun.

The Paper is accompanied by an album of photographs and a seismogram illustrative of the great earthquake.